IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application Serial No. 09/966,953
Filing Date ....September 27, 2001
Inventorship ....Kevin Collins
Applicant..Hewlett-Packard Company
Group Art Unit..2114
Examiner .... Le, Dieu Minh T
Confirmation No. 4853
Attorney's Docket No. 10006728-1
Title: Storage Device Performance Monitor

DECLARATION UNDER 37 C.F.R. §1.131

To: Commissioner for Patents
         P.O. Box 1450
         Alexandria, VA 22313-1450

I/We, Kevin Collins and Michael Fleischmann, declare:

1.   This declaration is being made in support of the allowability of claims 1-9, 11-19, 21-26, and 28-29 in the above-identified patent application (hereinafter referred to as "the invention").

2.   I/We are each co-inventors of the subject matter described and claimed in the patent application identified above, and are each co-inventors of each claim that this declaration is being made in support of.

3.   Each of the acts described herein was undertaken in the United States.

4.   Each of the exhibits was maintained as a business record by Hewlett-Packard Company in the normal course of business.

5.   Each of the dates redacted from the exhibits is prior to June 1, 2001.

6.   The identity of another Hewlett-Packard Company employee for whom it was determined did not make an inventive contribution to the invention is also redacted in Exhibit A.

13

10006728-1

7.   I/We determined that Kevin Collins would be primarily responsible for handling the patent preparation process, including preparing any necessary disclosure documents, interacting with patent counsel, and reviewing early drafts of the patent application, but that both Kevin Collins and Michael Fleishman would review at least the final draft patent application prior to filing with the U.S. Patent Office.

8.   Prior to June 1, 2001, I/We conceived of the invention. See Exhibit A, which is an invention disclosure record prepared by Kevin Collins in the normal course of business to describe the invention.

9.   Prior to June 1, 2001, Kevin Collins attended an invention disclosure meeting to describe the invention to outside patent counsel, Mark Trenner (hereinafter referred to as "outside patent counsel"), as documented in Exhibit B. Exhibit B is an attorney invoice submitted to Hewlett-Packard Company by outside patent counsel documenting time spent preparing this patent application. The initials MDT in the attorney invoice identify Mark Trenner.

10.   Prior to June 1, 2001, Kevin Collins reviewed potential prior art references related to the invention as provided to me by outside patent counsel, as documented in the attorney invoice (Exhibit B).

11.   Prior to June 1, 2001, Kevin Collins further described features of the invention to outside patent counsel for preparation of the patent application, as documented in the attorney invoice (Exhibit B).

12.   Prior to June 1, 2001, Kevin Collins received a first draft of the patent application as prepared by outside patent counsel (Exhibit C). Exhibit C is a draft patent application describing each of the currently claimed features of the invention. On or about that time I reviewed the first draft of the patent application and returned my comments to outside patent counsel, as documented in the attorney invoice (Exhibit B).

13.   On June 4, 2001, Kevin Collins received a second draft of the patent application as prepared by outside patent counsel, as documented in the attorney invoice (Exhibit B). On or about that time Kevin Collins reviewed the second draft of the patent application.
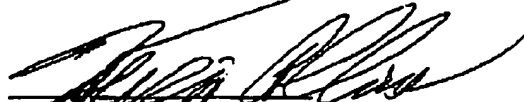
14.   On June 11, 2001, Kevin Collins attended a telephone conference with outside patent counsel to discuss comments regarding the second draft of the patent application, as documented in the attorney invoice (Exhibit B).

14

10006728-1

15.   On September 7, 2001, Kevin Collins received an email communication from outside patent counsel concerning potential prior art references related to the invention. I reviewed these references and returned my comments to outside patent counsel for preparation of the patent application, as documented in Exhibit D. Exhibit D is another attorney invoice submitted to Hewlett-Packard Company by outside patent counsel documenting time spent preparing this patent application. Again, the initials MDT identify Mark Trenner.

16.   On September 2001, Kevin Collins received a final draft of the patent application. On or about that time both Kevin Collins and Michael Fleischmann reviewed the final draft of the patent application. Both Kevin Collins and Michael Fleischmann signed the Declaration on September 26, 2001 indicating both of our approval of the final draft. See Exhibit E, which is a copy of the executed Declaration for this patent application.

17.   The patent application was filed by Hewlett-Packard Company on September 27, 2001, as evidenced by the US Patent Office filing date accorded this patent application.

18.   I/We further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Kevin Collins

Dated this __ day of April, 2005.

Michael Fleischmann

Dated this __ day of April, 2005.

15

EXHIBIT A
(Invention Disclosure Record)

16

—   —

Re: Invention Disclosure: Disc Performance Analysis Tool
          PD Number: 10006728
Dear Kevin Collins:

Thank you for submitting an Invention Disclosure Form dated ████████
relating to the above referenced invention. We have placed this
disclosure in our active disclosure list as a "NEW" disclosure and we
will review your disclosure at our next patent coordinator meeting.

Your disclosure has been assigned PD Number 10006728. You may call
this office and check on the status of your disclosure at any time by
using this PD Number.

Again, on behalf of HP, I want to thank you for submitting your
invention disclosure. Please bear in mind that you should treat all
information about this invention as confidential. Please contact T.
Grant Ritz at 970 898 0697 immediately if you need to disclose this
invention outside of Hewlett-Packard. Failure to do so may cause
forfeiture of your Hewlett-Packard rights.

Sincerely,

Legal Department
Intellectual Property Section

CC: Joe Gersch

Re: Invention Disclosure: Disc Performance Analysis Tool
        PD Number: 10006728

Dear ███████████████████████

Thank you for submitting an Invention Disclosure Form dated ████████
relating to the above referenced invention. We have placed this
disclosure in our active disclosure list as a "NEW" disclosure and we
will review your disclosure at our next patent coordinator meeting.

Your disclosure has been assigned PD Number 10006728. You may call
this office and check on the status of your disclosure at any time by
using this PD Number.

Again, on behalf of HP, I want to thank you for submitting your
invention disclosure. Please bear in mind that you should treat all
information about this invention as confidential. Please contact T.
Grant Ritz at 970 898 0697 immediately if you need to disclose this
invention outside of Hewlett-Packard. Failure to do so may cause
forfeiture of your Hewlett-Packard rights.

Sincerely,

Legal Department
Intellectual Property Section

CC: Joe Gersch

INVENTION DISCLOSURE

[hp]

PDNO 10006728

OVRU-FCS

DATE RCVD ████████

PAGE ONE OF ____

ATTORNEY TGR

Instructions: The information contained in this document is COMPANY CONFIDENTIAL and may not be disclosed to others without prior authorization. Submit this disclosure to the HP Legal Department as soon as possible. No patent protection is possible until a patent application is authorized, prepared, and submitted to the Government.

Descriptive Title of Invention:
Disc performance analysis tool

Name of Project:
DISC performance analysis tool

Product Name or Number:

Was a description of the invention published, or are you planning to publish? If so, the date(s) and publication(s):
no

Was a product including the invention announced, offered for sale, sold, or is such activity proposed? If so, the date(s) and location(s):
no

Was the invention disclosed to anyone outside of HP, or will such disclosure occur? If so, the date(s) and name(s):
no

If any of the above situations will occur within 3 months, call your IP attorney or the Legal Department now at 1-898-4919 or 970-898-4919

Was the invention described in a lab book or other record? If so, please identify (lab book #, etc.)
no

Was the invention built or tested? If so, the date:
no

Was this invention made under a government contract? If so, the agency and contract number:
no

Description of Invention: *Please preserve all records of the invention and attach additional pages for the following. Each additional page should be signed and dated by the inventor(s) and witness(es).*
A. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)
B. Advantages of the Invention over what has been done before.
C. Problems solved by the invention.
D. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc).

Signature of Inventor(s): Pursuant to my (our) employment agreement, I (we) submit this disclosure on this date: [   ].

Employee No.	Name	Signature	Telnet	Mailstop	Entity & Lab Name
319067	Kevin Collins	Kevin Collins	898-4672	45	4of1
			Telnet	Mailstop	Entity & Lab Name
Employee No.	Name	Signature	Telnet	Mailstop	Entity & Lab Name
Employee No.	Name	Signature	Telnet	Mailstop	Entity & Lab Name
Employee No.	Name	Signature	Telnet	Mailstop	Entity & Lab Name

(If more than four inventors, include additional information on another copy of this form and attach to this document)

INVENTION DISCLOSURE

COMPANY CONFIDENTIAL   PAGE _____ OF _____

Signature of Witness(es): *(Please try to obtain the signature of the person(s) to whom invention was first disclosed.)*

The invention was first explained to, and understood by, me (us) on this date: [

Full Name	Signature	Date of Signature

Full Name	Signature	Date of Signature

Inventor & Home Address Information: *(If more than four inventors, include addtl. information on a copy of this form & attach to this document)*

Inventor's Full Name

Street

City		State	Zip

Do you have a Residential P.O. Address? P.O. BOX	City	State	Zip

Greeted as (nickname, middle name, etc.)	Citizenship

Inventor's Full Name

Street

City		State	Zip

Do you have a Residential P.O. Address? P.O. BOX	City	State	Zip

Greeted as (nickname, middle name, etc.)	Citizenship

Inventor's Full Name

Street

City		State	Zip

Do you have a Residential P.O. Address? P.O. BOX	City	State	Zip

Greeted as (nickname, middle name, etc.)	Citizenship

Inventor's Full Name

Street

City		State	Zip

Do you have a Residential P.O. Address? P.O. BOX	City	State	Zip

Greeted as (nickname, middle name, etc.)	Citizenship

Description of Invention: *Please preserve all records of the invention and attach additional pages for the following. Each additional page should be signed and dated by the inventor(s) and witness(es).*

A. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)

B. Advantages of the invention over what has been done before.

C. Problems solved by the invention.

D. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc.).

Description of Invention:

A. Description of the construction and operation of the invention

Using a filter driver which intercepts all file system accesses we can determine the performance of disk drives themselves. We can separate out the overhead of the operating system and file system and get a detailed view of how long reads and writes took to specific disk drives. This tool can be used in competitive analysis and could be used to evaluate existing disks for their current performance levels. The tool would have a GUI that would give tabular as well as graphical representations of the data collected. The data from such a tool may also be used to provide insight into future disk problems.

B. Advantages of the invention over what has been done before

I'm not aware of a product which does this.

C. Problems solved by the invention

It enables people to assess the true performance of a disk/array in the process of a purchasing decision or a replacement decision. It may also be used to characterize current disk performance so that data may be moved to better performing storage and/or provide insight into a disk that may soon fail.

D. Prior solutions and their disadvantages

I'm not aware of prior solutions.

EXHIBIT B
(Attorney Invoice #1)

17   10006728-1

MAILED
09/28/01

DAHL & OSTERLOTH, L.L.P
555 17th Street, Suite 3405
Denver, CO 80202-3937
Tel: (303) 291-3200
Fax: (303) 291-3201

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— GR

July 03, 2001

Invoice No.:   11006
Tax ID No.: 84-1498957

Financial Administrator
Hewlett Packard Company
Legal Dept., Finance Sec., MS20BOB
P.O. Box 10301
Palo Alto, CA 94303-0890

RECEIVED

JUL 1 9 2001

H-P LEGAL FCS

RE: HP Docket No.: 10006728-1US   Attorney: T. Grant Ritz, Esq.
     U.S. Patent Application for "Storage Device
     Performance Monitor" of Collins, et al.

     Our File No.: HP.10006728-1

Professional Services

			Hours	Amount
	GWO	Review disclosurfe	0.40	80.00
	MDT	Meeting with inventor Kevin Collins in Fort Collins regarding disclosure	2.00	300.00
	MDT	Patent Application preparation; telephone conference with T. Grant Ritz regarding prior art search	5.20	730.00
	GWO	Discussioin with Mark Trenner regarding prior art search	0.50	100.00
	MDT	Review additional search results; e-mail to inventor Kevin Collins regarding same	0.70	105.00
	GWO	Review additional disclosure from inventor and discuss with Mark Trenner	0.60	120.00
	MDT	Review additional disclosure from Kevin Collins; Drawing preparation	4.00	600.00
	MDT	Patent Application preparation; drawing preparation	7.50	1,125.00
	MDT	Patent Application preparation; drawing preparation	4.30	645.00
	MDT	Patent Application preparation	6.80	1,020.00
	MDT	Patent Application preparation	6.80	1,020.00
	MDT	Patent Application preparation	6.80	1,020.00

Financial Administrator

Page   2

			Hours	Amount
	MDT	Patent Application preparation	7 50	1,125.00
	MDT	Patent Application preparation	3 30	495.00
	MDT	Edit Patent Application; forward draft of Patent Application to Kevin and T. Grant Ritz for review	1 00	150.00
06/01/01	GWO	Discussion with Mark Trenner regarding inventorship	0 40	60.00
06/04/01	MDT	Edit patent Application per inventor's comments; forward second draft to inventors and T. Grant Ritz for review	2 00	300.00
06/11/01	MDT	Telephone conference with Kevin Collins regarding second draft of Patent Application	0 20	30.00
06/13/01	MDT	Patent Application preparation	1 00	150.00
06/19/01	GWO	Review Patent Application	1 50	337.50
06/21/01	MDT	Finalize Patent Application	1.00	150.00
	GWO	Final review of case prior to filing	0.50	112.50

For professional services rendered

64.00 $9,855.00

Additional Charges :

06/21/01	Long Distance Telephone	12.32
06/15/01	Copy Charge	114.80
06/21/01	Postage	8.95

Total costs

$136.07

Total amount of this bill

$9,991.07

Balance due

$9,991.07

178427

EXHIBIT C
(Draft Patent Application)

18

10006728-1

STORAGE DEVICE PERFORMANCE MONITOR

Field of the Invention

5

The invention generally pertains to performance monitors for use with computer systems, and more specifically, to a method and apparatus for monitoring the performance of a storage device.

10

Background of the Invention

Computer systems are typically provided with access to one or more storage devices. The storage devices may be attached directly to the computer system itself. For example, a personal computer (PC) such as a laptop or desktop computer may include one or more attached storage devices such as a hard disk drive, a compact disk (CD), magnetic storage, etc. Alternately, or in addition to, the computer system may have access to remote storage devices, such as over a network. For example, a workstation may have remote access to a network storage device such as a fibre channel Storage Area Network (SAN), a Network Attached Storage (NAS) device, etc. Or for example, a workstation may have remote access to a shared hard disk drive or other storage device attached to a server or other workstation that is available over a network.

The performance of a storage device, whether attached or remote, depends on a number of factors, such as the extent of use, type of use, etc. Over time and with use, the performance of the storage device may decline or even fail altogether. Declining performance and/or complete failure of a storage device may result in lost data, time and money, not to mention

frustration for anyone needing access to the data stored thereon. In addition, when a storage device fails altogether, the data on the failed device may be irretrievable.

5   One solution for optimizing the performance of a storage device is to defragment it. During a defragmenting operation, similar files and file segments may be grouped together on the storage device so that these files and file segments may be more readily accessed. However, defragmenting operations often take time to perform, and may be interrupted if the storage device is accessed during the defragmenting operation. In addition,

10   defragmenting operations typically group all similar or like files with one another, without first assessing the need to do. As such, a time consuming defragmenting operation may not improve the performance of the storage device.

      When a storage device fails altogether, data recovery may include an

15   attempt to recover the data from the failed storage device itself. In some situations, the data may be recovered. However, such recovery may take considerable time before the data can be retrieved from the failed storage device and rewritten to another storage device. The data remains inaccessible during the recovery operation. In addition, this solution may be

20   costly depending on the type of storage media and the extent of the failure. In some circumstances, the data may not even be recoverable.

      Another, more common solution for data recovery, is to back-up data from one storage device to another storage device prior to a device failure. However, the user does not know when a storage device will fail, and hence

25   the user does not know when to perform the back-up operation. Device failures often start out as what are called "recoverable" failures. That is, when an attempt to access data on the storage device fails, the storage device itself may retry or make another attempt to access the data thereon. Alternately, the storage device may report the failed attempt to the operating

30   system, which may retry or make another call to the storage device to access the data thereon. In any event, when a retry is successful, nothing is reported to the user. As such, any potential problems with the storage device are

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"masked" to the user, and the user does not know of a potential failure of the storage device until it actually occurs.

Typically, the user must back-up data on the storage device to another storage device on a regular basis. However, even when data is backed-up on
5   a regular basis, the user still does not know when the storage device will fail. As such, some data may still be lost when the storage device fails. That is, the data added or changed after the last back-up may not be recoverable when the storage device fails. Although more frequent back-ups may reduce the amount of lost data when the storage device fails, back-up operations
10   take time to perform, and may slow other functions of the computer system while being performed. In addition, there may still be some data that is changed and/or added after the last back-up, and thus that data may be lost when the storage device fails.

15

Summary of the Invention

The inventors have devised an apparatus for monitoring performance of a storage device. The apparatus is preferably embodied in computer
20   readable program code that is stored on computer readable storage media. The apparatus may comprise program code for acquiring access information for the storage device; program code for analyzing the access information, wherein the access information is compared to a predicted failure of the storage device; and program code for responding to a decline in the
25   performance of the storage device prior to the predicted failure thereof. The program code for acquiring the access information may comprise program code for intercepting an error reported by the storage device, program code for measuring access time for the storage device, and/or program code for determining system overhead and program code for correcting the access
30   time for the system overhead. The program code for responding may comprise, for example, program code for backing-up data from the storage device, and/or reallocating data on another sector of the storage device. As another example, the program code for responding to the decline in the

HP 10006728-1   -4-

performance of the storage device may comprise defragmenting at least a portion of the storage device based on the access information.

A method for monitoring performance of a storage device is also disclosed. The method may comprise acquiring access information when the storage device is accessed; analyzing the acquired access information relative to a threshold value for the performance of the storage device; and responding to a decline in the performance of the storage device based on the analyzed access information. Acquiring the access information may comprise measuring access time for the storage device, correcting the measured access time for system overhead, and/or intercepting a failure report from the storage device. Responding to the declining performance of the storage device may comprise, for example, automatically backing-up data stored on the storage device, reallocating data to other sectors on the storage device, replacing the storage device, reporting the performance (e.g., to an administrator), defragmenting the storage device, etc.

Accordingly, the storage device may be defragmented and/or the files and file segments are reallocated thereon after a determination that such action is necessary to improve the performance of the storage device. In addition, the apparatus and method may determine how best to defragment and/or reallocate the storage device to optimize the performance thereof. Furthermore, the apparatus and method may monitor the performance of the storage device so that a response may be initiated prior to an actual failure of the storage device. For example, the data stored thereon may be moved prior to a failure, eliminating the need for expensive and time-consuming recovery operations.

Brief Description of the Drawings

Illustrative and presently preferred embodiments of the invention are illustrated in the drawings, in which:

-5-

FIG. 1 is a high level diagram of a computer system and a storage device, illustrating an embodiment of the apparatus for monitoring the performance of the storage device;

FIG. 2 illustrates an access information log for monitoring the
5   performance of the storage device;

FIG. 3 shows exemplary access information acquired for analysis according to an embodiment of the apparatus;

FIG. 4 shows exemplary access information acquired for analysis according to another embodiment of the apparatus;

10   FIG. 5 illustrates data stored on various sectors of the storage device;

FIG. 6 illustrates data segments stored on various sectors of the storage device after the data has been reallocated or defragmented;

FIG. 7 illustrates embodiments of a method for monitoring the performance of the storage device; and

15   FIG. 8 illustrates further embodiments of a method for monitoring the performance of the storage device.

Description of the Preferred Embodiment

20

FIG. 1 is a high level diagram illustrating an embodiment of the apparatus for monitoring the performance of a storage device 150. For purposes of illustration, the computer system 100 is shown comprising at least an operating system 110 and may further comprise applications 120
25   executed by the computer system 100. Although the storage device 150 is shown separately from the computer system 100, these components may be housed in a single unit. Also shown in FIG. 1 is a filter driver 130 for intercepting 140 communications (e.g., write commands 160, read commands 165) between the computer system 100 (e.g., the operating
30   system 110, an application 120) and the storage device 150. In addition, the filter driver 130 may also intercept 145 errors or failures 170 reported by the storage device 150 to the computer system 100. The access information (i.e., communications between the computer system 100 and the storage device

150, and other information related thereto, as explained below), may be stored in an access information log 200 for analysis thereof, according to the teachings of the invention.

5   The apparatus is preferably embodied in firmware and/or software (i.e., computer readable program code), stored in computer readable storage media and executed, for example, by the computer system 100. The computer readable program code may comprise: program code for acquiring access information when the storage device 150 is accessed; program code for analyzing the access information, wherein the access information is

10   compared to a predicted failure of the storage device 150; and program code for responding to a decline in the performance of the storage device 150 prior to the predicted failure thereof.

The program code for acquiring the access information may comprise, or operate in conjunction with, the filter driver 130 for intercepting

15   communications between the computer system 100 and the storage device 150. Such communications typically include "open", "close", "read", "write", "file creation", "error", etc. Mechanisms that allow applications to intercept such calls exist for use with operating systems, such as, Unix and Microsoft WINDOWS® operating systems.

20   It is understood that the computer system 100 may comprise any conventional computer, such as a desktop personal computer (PC), laptop PC, network workstation, network server, etc. In addition, the computer system 100 may comprise hardware and software that is not shown in FIG. 1. It is also understood that the firmware and/or software may comprise more

25   than one routine and/or subroutine, and may be embodied in separate components. In addition, the program code may be a stand-alone application, or may be a plug-in module for an existing application and/or operating system. Alternatively, the program code may be integrated into an application or operating system. In yet another embodiment, the program code can

30   reside at one or more network devices (not shown), such as an administrator terminal, a server, etc.

For purposes of illustration, FIG. 1 shows a single storage device 150. It is understood however, that the apparatus and method may be used with

-7-

one or more storage devices 150, or that a single storage device 150 may comprise one or more storage media (e.g., an array of disks). It is further understood that although the storage device 150 is preferably a hard disk drive, it can be any suitable fixed or removable computer readable storage

5   medium. For example, the storage device 150 may be, but is not limited to, a hard disk drive, zip disk, compact disc (CD), magnetic tape, etc. In addition, the storage device 150 may be any suitable network storage device including, but not limited to, storage attached to a personal computer (PC) or server, etc. It is further understood that the nature of the storage device 150

10   is immaterial to the teachings of the invention. That is, the storage devices 110-113 may be shared, password protected, etc.

FIG. 2 illustrates an access information log 200 for monitoring the performance of the storage device 150. The access information log 200 may be one or more suitable databases, data arrays, ASCII files, etc., for storing

15   access information (e.g., 240-290) that is acquired. Additional fields may also be provided, for example, for a correction factor 210 (e.g., for correcting the access time for overhead), device failure data 220 (e.g., for determining a threshold for responding to a decline in performance), and performance threshold data 230 (e.g., for responding to a decline in the performance of

20   the storage device 150, prior to failure thereof). Preferably, the access information log 200 may comprise acquired access information such as time 240 (e.g., a specific time or a period of time), reported access failures 250 (e.g., at time 240), and determined access times 260 (e.g., also at time 240), for monitoring the performance of the storage device 150 and responding to

25   a decline in performance thereof prior to a failure of the storage device 150, as discussed below. The access information log 200 preferably also may comprise acquired access information such as access duration 270, access frequency 280, and access location 290, for monitoring the performance of the storage device 150 and responding to a decline in performance thereof

30   by defragmenting all or a portion of the storage device 150, as discussed below.

According to one embodiment of the apparatus and method, the storage device 150 is monitored for "hidden" or "masked" signs of declining

-8-

performance. That is, when a recoverable failure occurs during an attempt to access the storage device 150, the storage device 150 may report an initial failure to the calling system or the operating system, which then retries the access command (e.g., an input/output (I/O) command) one or more times.

5   When one of the retries is successful, nothing is reported to the user, thus masking a potential or pending problem with the storage device 150.

According to the teachings of the invention, such a recoverable failure may be identified based on an analysis of the failures reported from the storage device to the computer system 100. That is, the filter driver 130 may

10   intercept reported errors or failures 170. In addition, the filter driver 130 and/or other suitable program code may also acquire other access information, such as, the location of attempted access on the storage device 150, amount of data, type of access, duration of access, etc. The access information may be written to a storage database (e.g., access information

15   log 200). Suitable program code may also be provided for analyzing the acquired access information. For example, the program code for analyzing the acquired access information may find an increasing number of failures for the storage device 150 and/or a particular area thereof. When the number of failures exceeds a threshold, program code for responding to the decline in

20   performance of the storage device 150 may warn the user of a potential or pending problem with the storage device 150.

FIG. 3 shows exemplary access information acquired for analysis according to the embodiment of the apparatus and method where a failure is reported from the storage device 150. This embodiment is further illustrated

25   by the data presented in Table 1.

TABLE 1

Time	Failures Per 1000 Transactions
T1	0
T2	3
T3	1
. . .	. . .

T100	77

In this example, the number of failures per thousand transactions is acquired and logged over time. For purposes of illustration, the data is shown by plot 300 in FIG. 3, wherein the number of failures per thousand transactions is

5   plotted along the y-axis 310 as a function of time, shown along the x-axis 320. The logged access information 350 indicates that during early operations of the storage device 150, there are very few failures reported by the storage device 150 to the computer system 100. For example, at times T1, T2, and T3 (see Table 1, above), there are very few failures reported.

10   However, with use and over time, the logged access information 350 indicates that the storage device 150 begins to report more access failures. For example, at time T100 (see Table 1, above), there are seventy-seven failures reported for every one-thousand transactions that occur.

According to the invention, the acquired access data may be

15   compared to a known or predicted failure 375 of the storage device 150. That is, based on past performance of comparable storage devices, it may be known that the storage device 150 may fail entirely when the storage device 150 experiences a number of recoverable failures (e.g., approximately 100 failures for every one-thousand transactions). Alternately, or in addition to,

20   the failure 375 may be derived or predicted to fail entirely when the storage device 150 experiences a number of recoverable failures (e.g., approximately 100 failures for every one-thousand transactions), based on statistical analysis of the logged access information (e.g., curve fit 355).

A performance threshold 370 may be determined based on the known

25   or predicted failure 375. Thus, when the access information indicates that the performance of the storage device 150 is approximately at the performance threshold 370, a response may be initiated to prevent loss of the data on the storage device 150. For example, a performance threshold 375 may be "seventy-five failures per thousand transactions", based on the predicted

30   failure 375 of "one-hundred failures per thousand transactions". Thus, for example, when the access information indicates that the performance of the storage device 150 is approximately seventy-five failures per thousand

transactions (e.g., seventy-seven reported failures at time T100 in Table 1, above), a response may comprise alerting the user that the storage device 150 is about to fail so that the user may replace it, automatically backing-up or reallocating data on the storage device 150 to an alternate storage device,

5   etc. As such, a response may be initiated prior to failure of the storage device 150 to prevent, or reduce the risk of, losing the data on the storage device 150 due to a failure thereof.

It is understood that the data shown in FIG. 3 and the data shown in Table 1 is merely illustrative of access information that may be acquired and

10   analyzed according to the teachings of the invention. The examples given above with respect to FIG. 3 and Table 1 are not intended to limit the access information to the values of this data or the type of data that may be acquired and analyzed according to the invention. In addition, these examples are not intended to limit the teachings of the invention in any other manner.

15   Furthermore, the data of FIG. 3 and Table 1 is not to be construed as actual data, and was not measured as such.

According to another embodiment, the storage device 150 is monitored for "hidden" or "masked" signs of declining performance. That is, when a recoverable failure occurs during an attempt to access the storage

20   device 150, the storage device 150 may retry the access command (e.g., an input/output (I/O) command) itself. When the retry is successful, nothing is reported back up the calling chain (i.e., to the computer system 100), thus masking a potential or pending problem with the storage device 150. Because the recoverable error or failure is not reported by the storage device

25   150, however, the error or failure is not directly viewable by the filter driver 130.

According to the teachings of the invention, such a recoverable failure may be inferred by analyzing a history of access times to various parts of the storage device 150. That is, when the storage device 150 retries the access

30   command (e.g., up to 10 times), a timer may be incremented until the access is successful. In addition, the filter driver 130 and/or other suitable program code may also acquire other access information, such as, the location of attempted access on the storage device, amount of data, type of access,

-11-

duration of access, etc. The access information may be written to a storage
database (e.g., access information log 200). Suitable program code may also
be provided for analyzing the acquired access information. For example, the
program code for analyzing the acquired access information may find
5   lengthening execution or access times for the storage device 150 and/or a
portion thereof. When the access time exceeds a threshold, program code for
responding to the decline in performance of the storage device 150 may warn
the user of a potential or pending problem with the storage device 150.

FIG. 4 shows exemplary access information acquired for analysis
10   according to the embodiment where an error or failure is not reported from
the storage device 150. This embodiment is further illustrated by the data
presented in Table 2.

TABLE 2

Time	Measured Access Time (ms)	Corrected Access Time (ms)
T1	0.3	0.1
T2	0.3	0.2
T3	0.4	0.3
. . .	. . .	. . .
T100	2.8	2.6

15

In this example, the access time for the storage device 150 is acquired and
logged over time. For purposes of illustration, the data is shown by plot 400
in FIG. 4, wherein the access time is plotted along the y-axis 410 as a
function of time, shown along the x-axis 420. The logged data may comprise
20   measured access time 450 and/or corrected access time 460. The exemplary
logged data indicates that during early operations of the storage device 150,
the access time for the storage device 150 is relatively fast. For example, at
times T1, T2, and T3 (see Table 2, above), the access time is less than 0.5
ms. However, with use and over time, the data 450 indicates that the storage
25   device 150 begins to slow. For example, at time T100 (see Table 2, above),
the average access time exceeds 2.5 ms, even once it has been corrected.

-12-

     The access time for the storage device 150 may be influenced by a
number of external factors, in addition to internal retries. For example, more
than one call may be made simultaneously to the storage device 150, the
load on the computer system 100 may impact the communications with the
5   storage device 150, etc. In addition, these, and/or other external factors may
influence the access time of the storage device 150 at various times, and
indeed, need not influence the access time at all during other times.
Therefore, the apparatus preferably comprises program code for correcting
the measured access time for these external factors. For example, the filter
10   driver 130 may also monitor other calls to the storage device 150, and based
on the number of simultaneous calls thereto, apply a correction factor to
determine the access time of the storage device 150. Or for example, the
operating system 110 may report the load on the computer system 100, and
based on the load, a correction factor may be applied to determine the
15   access time of the storage device 150. These are merely exemplary of
influences and solutions for correcting the measured access time therefor,
and other influences and solutions thereto are also contemplated as being
within the scope of the invention.

20

**HOW IS THE OVERHEAD DETERMINED OR WHERE IS IT ACQUIRED
FROM? THE KERNEL, A LOG FILE, PROGRAM CODE, ETC.?**

25   According to the invention, the acquired access data may be
compared to a known or predicted failure 475 of the storage device 150. That
is, based on past performance of comparable storage devices, it may be
known that the storage device 150 may fail entirely when the access time for
the storage device 150 slows to a known or expected value (e.g., 3.0 ms).
30   Alternately, or in addition to, the failure 475 may be derived or predicted to
fail entirely when the storage device 150 slows to a known or expected value
(e.g., 3.0 ms), based on statistical analysis of the acquired access
information (e.g., curve fit 455). Thus, a performance threshold 470 may be

determined based on the known or predicted failure 475. Accordingly, when the access information indicates that the performance of the storage device 150 is approximately the performance threshold 370, a response may be initiated to prevent loss of the data on the storage device 150. For example, a

5   performance threshold 475 may be an access time of 2.5 ms, based on the predicted failure of an access time of 3.0 ms. Thus, for examp e, when the access information indicates that the performance of the storage device 150 has an access time of approximately 2.5 ms (e.g., 2.6 ms at time T100 in Table 2, above), a response may be initiated. A response may comprise

10   alerting the user that the storage device 150 is about to fail so that the user may replace the device, automatically backing-up or reallocating data on the storage device 150 to an alternate storage device, etc. As such, a response may be initiated prior to failure of the storage device to prevent, or reduce the risk of, losing the data on the storage device 150 due to a failure thereof.

15   It is understood that the data shown in FIG. 4 and the data shown in Table 2 is merely illustrative of access information that may be acquired and analyzed. The examples given above with respect to FIG. 4 and Table 2 are not intended to limit the access information to the values of this data or the type of data that may be acquired and analyzed. In addition, these examples

20   are not intended to limit the teachings of the invention in any other manner. Furthermore, the data of FIG. 4 and Table 2 is not to be construed as actual data, and was not measured as such.

Another embodiment may comprise defragmenting at least a part of the storage device 150 in response to the declining performance thereof. A

25   storage device may become fragmented with use. However, when the fragmentation occurs only with respect to some of the data thereon, it may be inefficient to defragment the entire storage device 150. In addition, when the fragmentation occurs only with respect to data that is rarely accessed, it may be inefficient to defragment the storage device 150 at all. Therefore, the

30   invention contemplates efficiently defragmenting the storage device 150. For example, directories may be reallocated to sectors that are closer to the files each represents. Or for example, directories may be grouped on the storage device 150 in the middle of the device to increase the access speed thereof.

HP 10006728-1   -14-

Or as another example, the most frequently used files may be reallocated to
sectors in or near the center of the storage device 150 to increase the access
speed thereof. These, and other examples of efficiently defragmenting the
storage device 150 are contemplated under the teachings of the invention
5   and are discussed in more detail below with respect to FIG. 5 and FIG. 6.

**IS IT WELL KNOWN THAT FILES GROUPED TOWARD THE CENTER OF
THE DRIVE CAN BE ACCESSED FASTER?**

10   FIG. 5 illustrates a portion 500 of the storage device 150 having data
(e.g., A, B, F, G, etc.) stored on various sectors thereof (e.g., blocks of
sectors 510, 520, 530). The filter driver 130 and/or other suitable program
code intercepts calls (e.g., 160, 165) to and from the storage device 150, and
thus acquires access information, such as, the file or file segment identity,
15   the frequency with which each file or file segment is accessed, the location of
each attempted accesses, the duration that each file or file segment is
accessed, etc. According to the invention, this access information may be
stored in a suitable database (e.g., access information log 200). Exemplary
access information for the files and/or file segments shown in FIG. 5 is given
20   in Table 3. below.

TABLE 3

File	File Location -Sector(s)	Access Duration - Avg Time (sec)	Access Frequency - (No. Per Hour)
A	1, 2, 450,451	188	550
B	3, 1001	15	2
. . .	. . .	. . .	. . .
F	447	78	15
G	448	158	55
H	449	255	351
. . .	. . .	. . .	. . .
X	1002, 1003	37	7

HP 10006728-1   -15-

The exemplary access information in Table 3 indicates that the data "A" (e.g., a file, file segment, directory, etc.) resides at four different sectors on the storage device 150, which are identified by the access information. In addition, the average duration of each access of the data "A" is relatively

5   significant (i.e., 188 seconds), as is the average access frequency thereof (i.e., 550 times per hour). The data "B" resides at two different sectors on the storage device 150, which are identified by the access information. In addition, the average duration of each access of the data "B" is relatively insignificant (i.e., 15 seconds), as is the average frequency with which it is

10   accessed (i.e., twice per hour). Therefore, an analysis of this access information may indicate that the data "A" may be reallocated, while the data "B" need not necessarily be reallocated at this time, to efficiently defragment the storage device 150.

         The access information and analysis thereof may be used by the

15   invention to map the storage device 150, or portions thereof (e.g., portion 500), and to reallocate data thereon for optimal access thereto for the average use. FIG. 6 illustrates data (e.g., A, B, F, G, etc.) stored on various sectors (e.g., blocks of sectors 610, 620, 630) of the portion 500 of the storage device 150 after it has been at least partially defragmented and/or

20   the data has been reallocated thereon. For example, based on the above analysis of the data in Table 3, the data "A" may be reallocated to adjacent or nearby sectors on the storage device 150. In addition, the data "A" may also be reallocated to reside at or near the center of the storage device 150 (e.g., to the block of sectors 620). As such, the access speed of data "A" may be

25   increased and the storage device 150 may be efficiently defragmented.

         It is understood that the examples given above with respect to FIG. 5, FIG. 6, and Table 3 are provided to illustrate various embodiments of the invention. These examples are not intended to limit the scope of the invention thereto. The invention may also be used to defragment more than one

30   storage device. Likewise, the data may be reallocated and/or defragmented across more than one such storage device, or among more than one media within a single storage device (e.g., between partitioned drives). Other embodiments are also contemplated as being within the scope of the

invention. In addition, it is understood that the representations of sectors of the storage device 150 shown in FIG. 5 and FIG. 6, and the access information in Table 3 are not to be construed as actual representations and/or data, and was not measured or otherwise determined as such.

5   FIG. 7 illustrates embodiments of a method for monitoring the performance of the storage device 150. Generally, the method includes acquisition of access information (700), analysis of the acquired access information (701), and response to the analysis of the acquired access information (702). More specifically, acquisition 700 may comprise measuring

10   the access time in step 710, and optionally correcting the access time for overhead in step 715 The access time may also be logged over time, in step 730 (e.g., in the access information log 200). In another embodiment, acquisition 700 may comprise intercepting an error or failure reported by the storage device 150, and optionally logging the error or failure over time, in

15   step 730. Analysis 701 may comprise deriving a performance threshold (e g., 370, 470) in step 740. and/or comparing the logged access information to a performance threshold in step 750. The response 702 may comprise reporting the performance of the storage device 150 in step 761, and/or automatic back-up of the data on the storage device 150 (e.g., prior to failure

20   thereof) in step 763. Alternately, or in addition to, response 702 may comprise reallocating all or some of the data to another portion of the storage device 150 (e.g., to another sector), to another storage device 150, both in step 702, and/or replacing the storage device altogether, in step 764.

        FIG. 8 illustrates other embodiments of a method for monitoring the

25   performance of the storage device 150. Again, the method generally includes acquisition of access information (700), analysis of the acquired access information (701), and response to the analysis of the acquired access information (702). However, in the embodiments shown in FIG. 8, acquisition 700 may comprise determining the access location(s) for data on the storage

30   device 150 In step 800. In step 810, the access frequency of the data may be determined. In addition, or instead of, acquisition 700 may comprise determining the access duration of the data in step 820. Analysis 701 may comprise evaluating the location, frequency, and/or duration of access of the

-17-

data in step 830. Response 702 may comprise defragmenting the storage device, in step 840. Alternatively, or in addition thereto, data may be reallocated in step 762.

5   It is understood that the steps shown and described in FIG. 7 and in FIG. 8 are merely illustrative of various exemplary embodiments of the invention and the scope of the invention is not to be limited thereto. The invention may comprise other embodiments having additional or fewer steps than those shown and described above.

10   The invention has been described above and various embodiments thereof have been illustrated for exemplary purposes. It is understood, however, that other embodiments are also contemplated as being within the scope of the invention. For example, another embodiment may comprise a graphical user interface (GUI) with graphical and/or tabular representations of the access information and/or analysis thereof. Or for example, in another

15   embodiment, the invention may output a detailed view of the storage device and the performance thereof under various conditions (e.g., under various loads, with respect to certain applications and/or users, etc.). In yet another exemplary embodiment, the invention may output the results of a competitive analysis that may be used to evaluate the performance of existing storage

20   devices 150, storage devices under development, storage devices under consideration for purchase, etc. Yet other embodiments will readily occur to those skilled in the art in view of the teachings of the invention.

While illustrative and presently preferred embodiments of the invention have been described in detail herein, it is to be understood that the inventive

25   concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art.

HP 10006728-1   -18-

WHAT IS CLAIMED IS:

1.   A method for monitoring performance of a storage device, comprising:
acquiring access information for said storage device;
analyzing said acquired access information relative to a threshold
value for the performance of said storage device; and

5   responding to a decline in the performance of said storage device
based on said analyzed access information.

2.   A method as in claim 1, wherein acquiring said access information
comprises measuring access time for said storage device.

3.   A method as in claim 2, wherein acquiring said access information
comprises correcting said measured access time for system overhead.

4.   A method as in claim 1, wherein acquiring said access information
comprises intercepting an error reported by said storage device.

5.   A method as in claim 1, wherein acquiring said access information
comprises determining an access location on said storage device and
an access frequency for data stored thereon.

6.   A method as in claim 1, wherein acquiring said access information
comprises determining an access location on said storage device and
an access duration for data stored thereon.

7.   A method as in claim 1, further comprising logging said access
information over time.

8.   A method as in claim 7, wherein analyzing said access information
comprises deriving said threshold value based on said logged access
information.

HP 10006728-1   -19-

9.   A method as in claim 1, wherein responding to said declining
performance of said storage device comprises automatically backing-
up data stored on said storage device.

10.   A method as in claim 1, wherein responding to said declining
performance of said storage device comprises reallocating at least
some data on said storage device.

11.   A method as in claim 1, wherein responding to said declining
performance of said storage device comprises defragmenting at least
a portion of said storage device.

12.   An apparatus for monitoring performance of a storage device,
comprising:

computer readable storage media;

computer readable program code stored on said computer readable

5   storage media, comprising:

      a)   program code for acquiring access information for said
storage device;

      b)   program code for analyzing said access information,
wherein said access information is compared to a

10   predicted failure of said storage device; and

      c)   program code for responding to a decline in the
performance of said storage device prior to said
predicted failure thereof.

13.   An apparatus as in claim 12, wherein said program code for acquiring
said access information comprises program code for intercepting an
error reported by said storage device.

14.   An apparatus as in claim 12, wherein said program code for acquiring
said access information comprises program code for measuring

-20-

access time for said storage device, and wherein said access
information comprises at least said access time.

15.   An apparatus as in claim 14, wherein said program code for acquiring
      said access information comprises:
      a)   program code for determining system overhead; and
      b)   program code for correcting said access time for said system
5   overhead.

16.   A method as in claim 12, wherein said program code for responding to
      said decline in the performance of said storage device comprises
      defragmenting at least a portion of said storage device based on said
      access information.

17.   An apparatus as in claim 12, further comprising:
      an access information log;
      program code for logging said access information over time in said
access information log; and
5   program code for determining said predicted failure of said storage
device based at least in part on said logged access information.

18.   An apparatus as in claim 12, further comprising program code for
      deriving a threshold value for the performance of said storage device,
      wherein said program code for responding to said decline in the
      performance of said storage device responds when the performance
5   of said storage device satisfies said threshold value thereof.

19.   An apparatus as in claim 12, wherein said program code for
      responding comprises program code for backing-up data from said
      storage device.

HP 10006728-1   -21-

20.   An apparatus as in claim 12, wherein said program code for responding comprises program code for reallocating data to another sector of said storage device.

21.   An apparatus as in claim 12, further comprising a graphical user interface for reporting the performance of said storage device to a user.

22.   An apparatus for monitoring performance of a storage device, comprising:

      means for evaluating access of said storage device to determine the performance thereof; and

5   means for responding to a decline in the performance of said storage device prior to a predicted failure thereof.

23.   An apparatus as in claim 22, further comprising means for intercepting communication with said storage device, wherein said intercepted communication is evaluated to determine the performance of said storage device.

24.   An apparatus as in claim 22, further comprising means for measuring time to access said storage device, wherein said measured access time is evaluated to determine the performance of said storage device.

25.   An apparatus as in claim 22, wherein said means for responding to said decline in performance of said storage device comprises means for reallocating data thereon.

26.   A method for monitoring performance of a storage device, comprising:
      acquiring access information for data on said storage device;
      analyzing said acquired access information; and

reallocating at least some of said data on said storage device to

5   enhance the performance of said storage device based on said analyzed

access information.

27   A method as in claim 26, wherein acquiring said access information

comprises determining access location, access frequency, and access

duration for said data on said storage device.

HP 10006728-1   -23-

Abstract

An apparatus and method for monitoring performance of a storage device. Preferably, the apparatus is embodied in computer readable program code. The apparatus and method may acquire access information when the storage device is accessed and analyze the access information, wherein the access information is compared to a threshold value and/or a predicted failure of the storage device. The apparatus and method may also respond to a decline in the performance of the storage device based on the analyzed access information, and preferably prior to the predicted failure thereof.

5

EXHIBIT D
(Attorney Invoice #2)

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November 06, 2001

FILED
11-20-01

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TG-R.

RE: HP Docket No.   10006728-1US
     U.S. Patent Application for "Storage Device Performance Monitor"
     of Collins, et al.
Our File No.: HP.10006728-1

Invoice No.:   11233
Attorney: T. Grant Ritz, Esq.

Professional Services

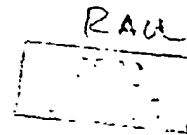|			Hours	Amount
9/4/01	MDT	Review related art references per T Grant Ritz's request	0.30	45.00
	GWO	Discussion with Mark D. Trenner regarding S.M.A.R.T. reference	0.30	67.50
9/7/01	MDT	Telephone conference with Grant regarding prior art references; e-mail Kevin regarding same	0.30	45.00
9/18/01	MDT	Amend claims in view of additional references; foreign claims and abstract; prepare new Information Disclosure Statement	0.40	60.00
	GWO	Discussion with Mark D. Trenner regarding claim amendments in light of S.M.A.R.T. reference	0.30	67.50
9/20/01	MDT	Finalize Patent Application in view of Amended Claims; new Information Disclosure Statement; letter and copies of same to T. Grant Ritz	0.70	105.00
			2.30	$390.00

For professional services rendered

Additional Charges :

9/4/01-Long Distance Telephone	
9/20/01	4.32
9/19/01 Postage	6.45
Copy Charge	99.20
Total costs	$109.97

Total amount of this bill	$499.97
Previous balance	$9,991.07
10/15/01 Payment - Thank You	($9,991.07)
Total payments and adjustments	($9,991.07)

Financial Administrator

RAU

Amount

Balance due

$499.97

APPROVED FOR PAYMENT

11-29-

Date

186112

EXHIBIT E
(Executed Declaration)

20

100C6728·

DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION

ATTORNEY DOCKET NO. 10006728-1

As a below named inventor, I hereby declare that:

My residence/post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

STORAGE DEVICE PERFORMANCE MONITOR

the specification of which is attached hereto unless the following box is checked:

( ) was filed on _____ as US Application Serial No. or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose all information which is material to patentability as defined in 37 CFR 1.56.

Foreign Application(s) and/or Claim of Foreign Priority

I hereby claim foreign priority benefits under Title 35, United States Code Section 119 of any foreign application(s) for patent or inventor(s) certificate listed below and have also identified below any foreign application for patent or inventor(s) certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE FILED	PRIORITY CLAIMED UNDER 35 U.S.C. 119	
N/A			YES ___	NO ___
			YES ___	NO ___

Provisional Application

I hereby claim the benefit under Title 35, United States Code Section 119(e) of any United States provisional application(s) listed below:

APPLICATION SERIAL NUMBER	FILING DATE
N/A	

U. S. Priority Claim

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (patented/pending/abandoned)
N/A		

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Customer Number [022879]

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Intellectual Property Administration
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Fort Collins, Colorado 80527-2400

Direct Telephone Calls To:

T. Grant Ritz, Esq.

(970) 898-0697

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Date 9-26-01

**DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION (continued)**

ATTORNEY DOCKET NO. **10006728-1**

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Inventor's Signature   Date 9/26/01

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Residence:

Post Office Address:

Inventor's Signature   Date

Full Name of # 4 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature   Date

Full Name of # 5 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature   Date

Full Name of # 6 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature   Date

Full Name of # 7 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature   Date

Full Name of # 8 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature   Date